fMRI Study of Response to Semantic Cueing During Verbal Learning in TBI

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Problem

Traumatic brain injury (TBI) is one of the leading causes of disability in young, otherwise healthy individuals. TBI is frequently associated with chronic memory problems, which cannot be predicted based on injury severity or injury site. Cognitive rehabilitation therapies, that include teaching strategies to improve memory, are used with the goal of improving memory functioning; however, not all patients benefit from such therapies and the reason for this is unclear. The current study used functional magnetic resonance imaging (fMRI) and a cued verbal memory paradigm to examine effects of semantic memory training on brain function in TBI. This research was supported by NIH R21HD050534.

Methods

All participants were right-handed adults, and groups (TBI; N=10, Controls; N=10) were matched for age (range = 20-58), gender (7 males), and years of education (mean = 13.25 years). Participants in the TBI group had suffered moderate to severe TBI and were within 6 months post injury. Participants were scanned before and after instructional specification (non-cued and cued) as they learned two types of word lists, presented visually. In one list type (Related), the words were semantically related in three categories, but the words were mixed so that no two words from the same category occurred together. The other list type (Unrelated) consisted of 12 non-semantically related words. Words were never repeated across runs and were counterbalanced across scans so that each block of words occurred equally in all orders.

Instructions in the Non-cued condition stated only that the words should be remembered but mentioned nothing about the semantic structure present in one list. Instructions in the Cued condition informed participants of the semantic structure and encouraged them to actively organize the word lists as they were learned.

Results

Analyses of Semantic Clustering scores for the Related word lists (# groupings by semantic category during recall), using repeated measures ANOVA (Group x Instruction Type), found an overall group difference, $F(1,18)=19.834$, $p<.001$, and a large effect for Instruction Type (Non-Cued vs. Cued), $F(1,18)=26.036$, $p<.001$, but no significant Group x Instruction Type interaction was found, $F(1,18)=.001$, $p=.965$. Thus, there was a general group difference in clustering score and both groups showed significant, and equal, improvement in clustering following cueing on the related word lists (Figure 1).
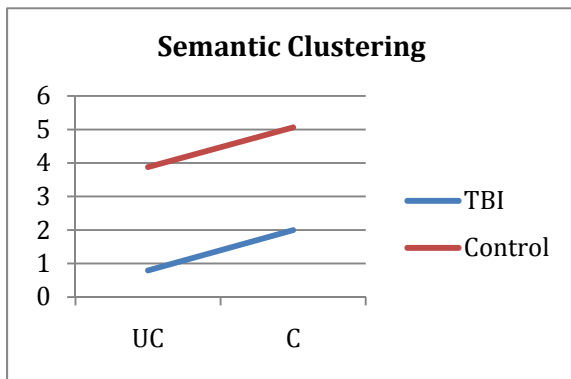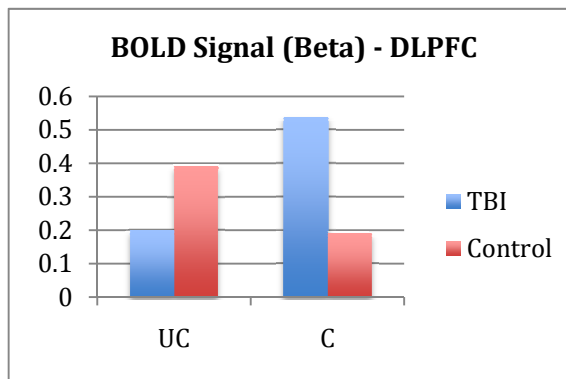

Figure 1

Figure 2

Analyses of fMRI data also showed a significant Group x Instruction Type interaction in the left dorsolateral prefrontal cortex (DLPFC), $F(2,18)=58.287418$, FDR $p<.05$ (Figure 3). BOLD signal in this area was higher for the Control group during the Uncued condition compared to the TBI group, and higher for the TBI group during the Cued condition compared to the Control group (Figure 2).

Figure 3. For display purposes, $p<0.000024$. Broadmann Area 44, Talairach coordinates (x=-42, y=8, z=31)

Conclusions

The left DLPFC is implicated in executive functioning, particularly in working memory. In this study, DLPFC was recruited during encoding of the word lists, and the level of recruitment was differentially modulated by strategy cueing in the TBI, though behavioral outcome was improved for both groups. This finding is interesting, and may suggest that the Control participants were able to spontaneously generate a memory strategy during the Uncued condition and, following cueing, did not need to devote as many resources, indicated by a decrease in BOLD signal. In comparison, TBI participants were unable to spontaneously generate a semantic clustering strategy for memory during the Uncued condition and increased semantic clustering in the Cued condition by increasing effort and compensatory neural processing in DLPFC.